TETRA TECH

MEMO

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From:	Tetra Tech, Inc. on behalf of Nā Pua Makani Power Partners
Date:	Thursday, December 28, 2023
Subject:	Nā Pua Makani Wind Project Post-Construction Mortality Monitoring Implementation Plan

1.0 Introduction

The Nā Pua Makani Wind Project (Project) consists of eight wind turbines near the town of Kahuku, on the north shore of Oʻahu. The Project is located on two tax parcels: TMK (1) 5-6-008:006, owned by the Hawaiʻi Department of Land and Natural Resources (DLNR) and TMK (1) 5-6-006:018, privately owned by Mālaekahana Hui West, LLC. TMK (1) 5-6-006:018 has existing agricultural uses within proximity to the turbines. The Project began commercial operations on December 11, 2020, preceded by a Project commissioning period beginning on August 16, 2020, during which turbines were operated periodically as a part of systems testing. Project commissioning lasted longer than anticipated because of Hawaiian Electric infrastructure upgrades necessary to meet transmission requirements. The Project is covered by an approved Habitat Conservation Plan (HCP) and the associated federal Incidental Take Permit and state Incidental Take License held by the permittee, Nā Pua Makani Power Partners, LLC (NPMPP). As part of the commitments in the HCP, NPMPP is required to conduct post-construction mortality monitoring (PCMM) surveys and report the results to the U.S. Fish and Wildlife Service (USFWS) and Hawaiʻi Department of Land and Natural Resources—Division of Forestry and Wildlife (DOFAW) to document potential impacts to wildlife.

In this document, Tetra Tech summarizes NPMPP's approach to conducting searches, testing searchers, managing scavenging of fatalities and vegetation within search plots, and reporting fatalities or injured wildlife discovered at the Project. This document updates earlier draft plans, based on input from DOFAW and USFWS staff (written input provided by DOFAW [November 18, 2022] and USFWS [November 29, 2022], verbal input provided during an agency meeting on November 9, 2022, and an agency site visit on March 3, 2023) and results of field method testing conducted in March and April 2023. In addition, we include a description of the approach used and results of our analysis of the proportion of expected carcass distribution included in the search plots for the listed species covered in the Project's HCP (Covered Species). The search plots were initially delineated during the commissioning process once the final site conditions were

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established; i.e., after final grading and re-seeding activities were complete and temporary storage materials had been removed. Based on changes in the search strategy responsive to agency input, Tetra Tech revised the delineation of active agricultural areas and field procedures to allow for incorporation of data from these searches into the estimation of fatalities. Supplemental agricultural search plots have been included in analyses to estimate take beginning in June 2022. Tetra Tech has calculated the proportion of the carcass distribution searched based on the current best available science and consistent with recommendations from USFWS and DOFAW described in the HCP.

2.0 Background

Tetra Tech prepared a preliminary PCMM plan (2016 PCMM Plan) as part of the Project's HCP (Tetra Tech 2016). The 2016 PCMM Plan described two spatial plots within which PCMM monitoring would occur. All standardized searches occur within these plots, but not all the area within each of these plots are searchable.

- **50 percent maximum blade tip height (MBTH) plot (50% MBTH plot)** – This is a square search plot centered on each turbine, with sides that are equal to the turbine's MBTH. Almost all bat fatalities are expected to occur within this area (see Section 4.0).
- **75% MBTH plot** – This is a search plot with a square outer perimeter, with sides that are equal to 150 percent of the turbine's MBTH and excludes the interior 50% MBTH plot (see Figure 1). The 75% MBTH plot is centered on each turbine. Almost all the bird species covered by the HCP (Covered Bird Species) fatalities are expected to occur within the combined area encompassed by the 50% MBTH and 75% MBTH plots combined (see Section 4.0).

The 2016 PCMM Plan identified certain site conditions that would challenge NPMPP's ability to search portions of these plots. These conditions include:

- **Agricultural areas** – The 2016 PCMM Plan acknowledged potential challenges in conducting fatality searches in areas where search plots overlapped with agricultural activities. These areas were deemed challenging due to potential conflicts with agricultural land use, such as concerns for damaged crops, unsafe conditions, and lack of land control in these areas (e.g., NPMPP is not authorized to manage vegetation within agricultural areas).
- **Steep terrain and areas where vegetation could not be maintained** – The 2016 PCMM Plan defined these areas as not searchable using traditional methods. This is because vegetation management cannot be safely performed in areas with steep terrain or where trees have not been removed and the terrain graded. As a result, these areas cannot be searched thoroughly nor safely. In general, these non-searchable areas include areas with steep terrain and areas that were not grubbed and graded during construction of the Project.

During March through November of 2020, Tetra Tech and NPMPP reviewed the site terrain, land use, and associated ability of NPMPP to implement effective search strategies at each of the Project turbines. In this process, Tetra Tech and NPMPP delineated searchable areas at each of the Project turbines and engaged with the private landowner of TMK (1) 5-6-006:018 to consider how searches that did not conflict with agricultural land use could be implemented in crop areas.

Based on extensive discussion with USFWS and DOFAW, NPMPP and Tetra Tech have investigated additional strategies and hired and trained additional personnel to allow for the inclusion of agricultural areas within the delineated searchable areas. These adjustments required:

- Extensive and regular outreach to the tenant farmers who farm agricultural areas adjacent to turbines 6 – 9,
- Hiring and training an additional canine search team to perform specialized searches associated with the agricultural search plot requirements,
- Revised delineation of agricultural search plots to identify individual searchable subplots that are likely to be managed consistently over time,
- Enhanced safety measures to minimize the risk of exposure of the canine search teams and HCP compliance biologist to chemical sprays used by tenant farmers as well as aggressive loose dogs.
- Coordination with the private landowner, and
- Development and experimental implementation of novel bias correction testing methods that minimized the risk of impacts to agricultural crops within the search areas.

Tetra Tech initiated a month of field testing the methods in June 2022, and the results suggested it is reasonable to incorporate data using these methods into the estimation of take analysis. Following additional agency input in November 2022 and March 2023, Tetra Tech implemented additional carcass persistence testing to refine carcass persistence estimates. The results of these assessments and consultations are incorporated in the PCMM plan outlined in sections 3.0 – 5.0, below.

3.0 Post-construction Monitoring Plan

3.1 Search Area Delineation

In March 2020, Tetra Tech delineated potential search plots within the 50% MBTH and 75% MBTH plots. The delineations included areas that were cleared during construction and other areas cleared pre-construction where vegetation could be safely maintained through mowing or other mechanical means, to maximize the likelihood of fatality detection based on carcass distribution. These areas were refined during a follow-up series of site visits in November 2020 based on the final Project topography, as constructed. During the November 2020 site visits, a GPS device was used to delineate the boundaries of the searchable area within each search plot, and physical markers were placed to facilitate management activities (e.g., mowing, scavenger trapping) and define search plot boundaries for canine search teams. These delineated areas were expanded in

May – June 2022 to allow for inclusion of additional search plots (agricultural use areas) in the analysis of potential take of the Covered Species. The areas within the 50% MBTH and 75% MBTH search plots were divided into three mutually exclusive categories:

- **Searchable Area** – Includes roads, pads, and adjacent areas that were cleared during Project construction or were already cleared and can be practically maintained in low-growing vegetation through regular mowing (i.e., slopes of less than 15 percent; Figures 2 – 3; hereafter, Standardized Search Plots). Data from these Standardized Search Plots will be used in statistical analysis to estimate observed and unobserved fatalities at the Project, and this data will be supplemented by results from individual supplemental search plots (Supplemental Search Plots) meeting criteria described below.
- **Supplemental Search Area** – Includes individually delineated Supplemental Search Plots within active and fallow agricultural areas in the 50% MBTH and 75% MBTH plots where NPMPP can at least periodically safely and effectively perform fatality searches with the canine search team. NPMPP does not exercise control over agricultural practices on these lands, but where and when possible and safe to do so, these areas are searched with a trained canine search team.[1] Due to the dynamic conditions of these areas (e.g., the periodic presence of aggressive dogs, use of agricultural chemicals requiring the cancellation of a search for the health and safety of the canine search team, the presence of tender crops likely to be damaged by the canine search team, or the presence of extremely dense or netted crops that cannot be effectively searched), data from Supplemental Search Plots will be evaluated each quarter for consistency. If the probability of a carcass persisting to the next search and being found exceeds 25 percent[2], the data from that Supplemental Search Plot will be included in the statistical analysis for take estimation (sections 4.0 – 5.0). Based on bias correction trial results from June 2022 – March 2023 NPMPP and Tetra Tech expect that this will result in the inclusion of any Supplemental Search Plot that can be searched approximately every 3 weeks.[3]
- **Non-searchable Area** –Includes: steep slopes (greater than 15 percent; Figures 2 – 3); areas not cleared prior to or during Project construction; areas described as unmanaged vegetation in the 2016 PCMM Plan; and specific agricultural areas around Turbine 9 and north of Turbine 8 where the consistent presence of uncontrolled aggressive dogs makes

[1] NPMPP has worked diligently with the private land owner and tenant farmers to maximize their ability to perform safe and effective searches within the Supplemental Search Plots. These efforts include the creation of bilingual outreach materials, regular outreach with a bilingual interpreter to reinforce outreach messages and request that dogs be penned on search days. However, the language barrier, number of independent tenant farmers (approximately four independent residences/families and associated workers), and the lack of accountability result in a regular lack of compliance with requests for notification and limitation on activities.

[2] Lower probabilities of detection for search plot areas that individually capture very small proportions of the carcass distribution do not significantly impact the estimate of the overall probability of carcass detection.

[3] The probabilty of a carcass persisting to the next search (*r*) is an output from the single-year module in Evidence of Absence (Dalthorp et al. 2017). Based on results of carcass persistence trials to-date and using search intervals of approximately every 3 weeks, values of *r* for bat and bird surrogates have been close to 0.25.

the performance of regular searching by the canine search team unsafe.[4] Non-searchable agricultural areas are evaluated approximately monthly to consider if conditions have changed sufficiently to warrant inclusion as a Supplemental Search Plot. Based on that evaluation, if the HCP compliance biologist and canine search team determine it is probable that a search plot comprising at least 5 percent of the carcass distribution for birds or bats at that individual turbine can be safely and effectively searched at least once every three weeks, then that search plot will be reclassified as a Supplemental Search Plot.

The results of the current delineation appear in Figure 1.

NPMPP's lack of control over agricultural practices (including the use of chemicals, the presence of aggressive dogs, and the characteristics of planted crops) occurring on the privately-owned parcel means this driver for excluding agricultural areas that cannot be searched regularly from the analysis is unlikely to change over time. NPMPP will continue to work with the resident farmers to attempt to incorporate additional areas into the described approach, but the dynamic nature of the agricultural lands will likely necessitate the exclusion of data from some individual Supplemental Search Plots from the analysis each quarter.

3.2 Searches

Two general types of searches occur at the Project, standardized searches and supplemental searches. Standardized searches are performed within the Searchable Area (Section 3.1), as this is the area within which NPMPP can manage Project conditions to allow for the implementation of a safe and effective PCMM program. Supplemental searches occur in areas where NPMPP does not have land use control and searches are subject to the feasibility of performing searches based on existing conditions.

3.2.1 Standardized Searches

To document potential Project impacts on Covered Species, NPMPP initiated standardized carcass searches to coincide with the operation of the turbines. Turbines began to operate on August 16, 2020, during a 4-month-long Project commissioning process. During this period and after the initiation of commercial operations (December 11, 2020), carcass searches have occurred and will continue to occur weekly[5] at all Project turbines throughout the year.

[4] Areas described as unmanaged vegetation in the 2016 PCMM Plan were defined as areas within the 75% MBTH plots "where existing vegetation allows searchers a reasonable opportunity to observe a large bird fatality." However, based on results from a March and November 2020 site visits, no unmanaged vegetation areas "where existing vegetation allows searchers a reasonable opportunity to observe a large bird fatality" or bat fatality exist outside of the supplemental (agricultural) search plots.

[5] Searches may be delayed for human safety or other unforeseen circumstances. If any search is delayed, it will be scheduled for the next available opportunity. Significant adjustments (search delays of greater than 3 days) to the search schedule will be reported in the Project's HCP compliance reports and USFWS and DOFAW will be notified.

The search interval may be adaptively managed in consultation with USFWS and DOFAW based on the results of carcass persistence trials (Section 3.5.1) if scavenger control efforts (Section 3.6.1) are insufficient to meet carcass persistence goals or if carcass persistence times are longer than expected. Carcass persistence data of surrogates for both bats and Covered Bird Species will be evaluated to ensure any adjustments to search interval are appropriate. At a minimum, the search interval will be managed to maintain mean carcass persistence times for bat and Covered Bird species surrogates that are longer than the search interval within the Standardized Search Plots.

The Project experiences annual dry (April – November) and wet (December – March) seasons. These seasons are associated with differences in plant growth, which could affect carcass visibility or scavenger densities; however, weekly vegetation management and scavenger control measures (see Section 3.5) have demonstrated a high probability of carcass availability for the next search throughout dry and wet seasons. Because turbine collision-related fatalities of the Hawaiian hoary bat have been documented on Oʻahu and other islands throughout the year, the weekly search interval is being implemented in both the dry and wet seasons. This search interval may be adaptively managed in consultation with DOFAW and USFWS based on carcass persistence and the potential implementation of other adaptive management approaches (Section 3.6.1).

3.2.2 Field Methods

Canine search teams will cover the entire searchable portion of each standardized search plot while under voice control of their handler or on-leash; however, if canine search teams are unavailable or it is unsafe to perform searches with canines, human searchers will walk transects spaced at approximate 20 feet within the search plot, looking for fatalities. Should fatality searches be performed by human searchers, these search efforts will be analyzed using searcher efficiency trial results from human searches, and NPMPP will notify USFWS and DOFAW regarding the details (reason, scale, and period) of the planned implementation of human searches.

3.2.2.1 Documentation of Turbine-Related Fatalities

All carcasses found during standardized carcass searches will be labeled with a unique number, and searchers will record information as described in the joint agency downed wildlife protocol (Downed Wildlife Protocol; DOFAW and USFWS 2020).

This information includes:

- Date and time observed;
- Location (GPS coordinate and distance/direction from the closest turbine);
- Habitat (managed landscape, road and pad, agricultural area, or unmanaged vegetation);
- Turbine operation data;
- Weather information;
- Moon phase;

- Presence of water and grazing activity (bats only);
- Description of the carcass condition;
- Comments relating to field observations associated with the potential cause of death or condition of the carcass (e.g., species, sex, age); and
- Actions taken by the observer.

A series of photographs will be taken for all fatalities. Photographs will include in-situ photos documenting the fatality as found and, if permits are in place, a series of ex-situ photographs that will highlight any distinguishing characteristics which may be useful in identification. If a carcass is removed from the field by NPMPP or subcontractors, a copy of the field data will always be kept in a separate bag with the carcass. Following a search day, searchers will complete a summary, reporting: names of the searchers, date, fatalities found, and turbines searched.

3.2.2.2 Reporting Protocol and Collection Procedures

Downed birds or Hawaiian hoary bats may be found dead or injured during standardized scheduled searches or incidentally. The observer or a Project representative will report any Migratory Bird Treaty Act (MBTA) or Covered bird or bat fatality (or injured animal) to the approved agency contacts via e-mail or by phone as described in the Downed Wildlife Protocol (DOFAW and USFWS 2020). All wildlife fatalities and injuries will also be documented in the HCP annual report (Section 8.0). Injured animals will be transported to an approved wildlife rehabilitation clinic unless otherwise directed by the designated agency representatives (DOFAW and USFWS 2020).

The final disposition of any carcasses collected will be based on the Downed Wildlife Protocol and input from designated agency representatives (DOFAW and USFWS 2020). Carcasses of non-listed species will be collected to use, as appropriate, for searcher efficiency or carcass persistence trials, or disposed of at an approved location, as directed by applicable permits.

3.3 Supplemental Search Plots and Incidental Detections

Searchers or Project personnel may discover (or be notified of) bird or bat carcasses incidental to scheduled carcass searches (e.g., outside of regularly scheduled search times or outside of designated search plots [Section 3.1 – 3.2]; see Section 6.0). For each incidentally discovered bird or bat carcass, the searcher or designated downed wildlife contact person will identify, photograph, and record data using the same protocol used for carcasses found during scheduled searches. Such carcasses, however, would be coded as incidental discoveries. Carcasses found within Standardized Search Plots or Supplemental Search Plots (used in the analysis), but outside of regularly scheduled search times will be included as observed for the purposes of estimating take using Evidence of Absence (Dalthorp et al. 2017) provided there is a greater than 50 percent probability (based on the most recent Project-specific carcass persistence and searcher efficiency data) the carcass would have remained available to be found and discovered during the next scheduled search.

NPMPP understands the importance of documenting Project impacts as accurately as practicable, and therefore, NPMPP is conducting searches in the Supplemental Search Plots and using this data in the statistical models to estimate Project impacts where and when conditions allow. Based on current conditions, Supplemental Search Plots can be searched in the delineated agricultural areas adjacent to turbines 6, 7, and the southern half of Turbine 8. Aggressive dogs are typically present in the agricultural areas north of Turbine 8 and west of Turbine 9, posing a risk to the health and safety of the canine searcher; therefore, these areas cannot be searched; however, also see Section 7.0 regarding regular evaluation of these areas for potential inclusion as Supplemental Search Plots. Upon arrival, the canine handler evaluates the Supplemental Search Plot for two primary conditions that would pose a health and safety risk and obviate a planned search:

- The presence of a loose dog in or near the Supplemental Search Plot or
- Evidence of recent spraying of herbicide, insecticide, or other chemicals in the Supplemental Search Plot

Results from searches in Supplemental Search Plots increase the probability of detecting Covered Species fatalities thereby improving our understanding of potential Project impacts to the Covered Species. This approach provides a better understanding of Project impacts by increasing the proportion of estimated take that is likely to be observed. Using the associated data as described (see Section 3.1) allows NPMPP, USFWS, and DOFAW to leverage additional data in evaluating Project impacts while respecting the limitations on land use management imposed on NPMPP by their lease agreement.

3.4 Carcass Persistence and Searcher Efficiency Trials

3.4.1 Carcass Persistence Trials

The objective of carcass persistence trials is to document the length of time carcasses persist in the search plot before removal and thus are available to be found by searchers. Resulting data are then used to provide an adjustment for study bias introduced by sources of carcass removal (e.g., scavengers). Additionally, the length of time carcasses persist helps determine the frequency with which carcass searches should be conducted, with the goal of maintaining a high probability that a fatality will be available to be found by a searcher. Possible differences in carcass persistence rates due to season or carcass size will be taken into account when evaluating the effect of carcass persistence rates on fatality estimates by performing trials at least quarterly.

Field Trials

Carcasses used in the trials will be selected to represent the range of sizes found among the Covered Species, with species selection ultimately determined by availability. For the Newell's Shearwater, Hawaiian coot, Hawaiian gallinule, Hawaiian stilt, Hawaiian duck, Hawaiian goose, and Hawaiian short-eared owl, carcasses may include MBTA Special Purpose Utility Permit and Hawai'i Special Use Permit covered seabirds (e.g., wedge-tailed shearwaters), if available; otherwise, surrogates for these species could include commercially and locally available adult game birds or

cryptically colored chickens. Surrogates will also be used to simulate bat carcasses. Research by Hale and Karsten (2010) found that bats persisted on average 3 days longer than mice, which are often used as surrogates for bats in field trials, and shorter persistence times for these rodents resulted in an upward bias of fatality estimates. Although such a bias could result from the use of rats as surrogates for bats, for consistency with other post-construction mortality studies in Hawai'i, carcasses of small dark-colored rats will be used to simulate bats. The types of carcasses used as surrogates may be adaptively managed if conditions change.

Standardized Search Plots

One carcass persistence trial will be conducted per quarter with approximately 10 carcasses of each type (bird or bat surrogate) placed per trial, depending on carcass availability. This sample size results in a goal of 40 total trial carcasses per size class used in carcass persistence trials for an entire year, assuming enough surrogate carcasses are available. The trials will be spaced out within each quarter to capture the potential effects of varying weather, vegetation conditions, and scavenger densities. The resulting carcass persistence data will be incorporated into the estimation of adjusted take.

Carcass persistence trial carcasses will be placed at random locations within the Standardized Search Plots. Field personnel deploying, checking, and recovering carcasses wear nitrile gloves to minimize the risk of odor transfer and mimic the occurrence of a natural fatality. Prior to initiating the trial, a set of random locations will be generated to determine the location of trial carcasses. These locations will subsequently be loaded into a GPS to allow the accurate placement of the carcasses by field personnel. Each trial carcass will be discreetly marked with a small tag so that it can be identified as a study carcass if it is found by searchers or Project personnel. Carcasses will be dropped from waist high and allowed to land in a random posture.

For each trial, personnel will monitor the trial carcasses over a 28-day period.[6] Carcass checks will occur on days 1, 2, 3, 4, 5, 6, 7, 10, 14, 17, 21, and 28 unless deviation from this schedule is necessary for human health safety, or other unforeseen circumstances. Carcasses will be checked daily during the first 7 days of the trial to obtain a precise estimate of carcass persistence probability because small differences in persistence time at the lower end of the scale can have a large effect on the adjusted number of fatalities. As the trial extends beyond the search interval in length, trial carcasses will be checked less frequently because the adjusted number of fatalities is not as sensitive to changes of a day or two in persistence time at the latter stages of a persistence trial. Following completion of the 28-day carcass persistence trial, any carcasses remaining will be collected and disposed of consistent with MBTA Special Purpose Utility Permit and Hawai'i Special Use Permit requirements.

During each check day, the condition of the trial carcass will be recorded as intact (normal stages of decomposition), scavenged (feathers pulled out, chewed on, or parts missing), feather spot (only

[6] Although not anticipated, game camera monitoring of carcasses may be implemented in lieu of human carcass checks.

feathers left), or completely gone. The carcass will be considered completely gone when the individual checking the carcass considers it highly improbable that the carcass would be detected or identified by a naïve searcher (e.g., only the carcass tag and the foot of a mouse are visible). Changes in carcasses condition will be cataloged with pictures and detailed notes; photographs will be taken at placement and any time major changes in carcass condition have occurred.

Supplemental Search Plots

Carcass persistence trials used to assess carcass persistence probabilities for the Supplemental Search Plots may require adjustments to standard protocols to minimize the risk of damage to sensitive or newly planted crops. When the highly trained and motivated canine searchers detect a carcass, they quickly work their way to the source of the odor with almost complete disregard for their surroundings. Placing significant numbers of carcasses within Supplemental Search Plots where crops may be dense and challenging to move through or delicate and easily damaged likely would result in damaged crops and a loss of search privileges.[7] Therefore, until March 2023, carcass persistence trials applied to the Supplemental Search Area were placed in surrogate agricultural areas with conditions similar to those of the Supplemental Search Plots but where canine searches cannot take place because of the regular presence of uncontrolled dogs (see Section 3.4, Figure 1). Carcass persistence measured in these un-searched surrogatelocations likely underestimates true carcass persistence times because carcasses there are checked by a human searcher alone and loose dogs occur more frequently in these plots.[8] Other than the location of theses carcass persistence trials occurring outside the area being actually searched, all elements of these trials were managed consistent with protocols used for the trials performed in the Standardized Search Plots.

Beginning in March 2023, NPMPP initiated testing of carcass persistence in both searched and unsearched agricultural areas to assess differences in the probabiliy of persistence between these two approaches. Following a 3-month trial period, NPMPP anticipates continuing carcass persistence trials only within the Supplemental Search Plots unless crop damage or other conditions require a change. If NPMPP needs to implement carcass persistence trials in Non-searchable agricultural areas again, NPMPP with notify USFWS and DOFAW of the details of the implementation including the scale, period, and reason for the change.

One carcass persistence trial will be conducted per quarter with approximately 5 carcasses of each type (bird or bat surrogate) placed per trial, depending on carcass availability. This sample size results in a goal of 20 total trial carcasses per size class used in carcass persistence trials for an entire year, assuming enough surrogate carcasses are available.

[7] Crops vary across the Project area and are periodically rotated or replanted, making the conditions at the site very dynamic.

[8] Trial carcasses are often moved within a search plot by scavengers. A moved carcass is more likely to be found by a canine and missed by a human searcher.

3.4.2 Searcher Efficiency

The objective of searcher efficiency trials is to estimate the percentage of available bird and bat fatalities that searchers can find. The ability of searchers to detect carcasses is influenced by several factors including the skill of an individual searcher in finding the carcasses, the vegetation composition within the search plot, and the characteristics of individual carcasses (e.g., body size, color). Estimates of searcher efficiency are used to adjust fatality counts for detection bias.

Field Trials

Carcasses used in searcher efficiency trials will be selected to represent the variability of Covered Species that could be found during scheduled searches. Acquisition of carcasses for searcher efficiency trials will be the same as described for carcass persistence trials (Section 3.5.1).

Standardized Search Plots

Searcher efficiency trials will be conducted as part of post-construction monitoring efforts during all years standardized carcass searches are conducted. Trials will be conducted monthly and spaced out within each quarter to capture the potential effects of varying weather and vegetation growth. Three to five carcasses from each of two size classes (bird and bat surrogates) will be included in the trials resulting in a goal of 80 trial carcasses (40 per size class) for an entire year, assuming enough surrogate carcasses are available. To meet sample size goals, the number of trial carcasses placed may be adjusted in any given season to ensure enough carcasses for each size class are available for detection and not removed by scavengers or other mechanisms. "Available for detection" means a carcass was found by searchers or missed by searchers but recovered following testing.

Personnel conducting the searches will not know when trials are conducted or the location of the detection carcasses, and procedures will incorporate testing of each search team used at the Project. All carcasses will be placed by a tester at pre-determined random locations within delineated search plots prior to the searcher's arrival. The tester will wear nitrile gloves to minimize the risk of odor transfer and mimic the occurrence of a natural fatality. The tester will place the carcasses prior to the scheduled carcass search so that carcass searchers are not aware that they are being tested. Each trial carcass will be discreetly marked by a small tag so that it can be identified as a study carcass upon recovery, then the carcass will be dropped from at least waist high and allowed to land in a random posture. During the carcass searches, searchers will collect trial carcasses found and record their number and location. Immediately following the search effort with a searcher efficiency trial, the tester will attempt to recover any undetected carcasses. The number of carcasses available for detection during each trial (i.e., trial carcasses found by carcass searchers or missed by searchers and recovered after testing) will be recorded following the trial. Carcasses which were not found by searchers and were not recovered following testing are assumed to have been removed by scavengers or other causes and to have not been available for detection during the trial and therefore will be excluded from the analysis. Solo human searches are expected to be very rare. If scheduled searches are performed by human searchers without canine

assistance, solo human searcher efficiency will be tested with a minimum of 5 trial carcasses from each of the two size classes (bird and bat surrogates) per quarter.

Supplemental Search Plots

Searcher efficiency trials conducted in the Supplemental Search Plots are conducted using the same approach as used in the Standardized Search Plots. Trials will be conducted monthly and spaced out within each quarter to capture the potential effects of varying weather and vegetation growth. One to three carcasses from each of two size classes (bird and bat surrogates) will be included in the trials resulting in a goal of 40 trial carcasses (20 per size class) for an entire year, assuming enough surrogate carcasses are available.

3.5 Search Plot Management

3.5.1 Scavenger control

Based on carcass persistence data from the Kahuku Wind Farm (Tetra Tech 2019), NPMPP anticipated that scavenger control efforts would be required to meet the goal of achieving mean carcass persistence times for surrogates of the Covered Species to be one week (the planned search interval) or longer. Scavenger control efforts were initiated in February 2021 with the deployment of 100 traps. Traps are distributed throughout the Project area with approximately equal spacing along Project roads and adjacent to turbine pads. This coverage is designed to reduce scavenger densities across the Project area including Standardized Search Plots and Supplemental Search Plots; however, specific targeted distribution of traps within the Supplemental Search Plots cannot be managed safely.[9] Carcass persistence times have increased under this management approach and provide a high probability that a carcass will persist until the next search. NPMPP may periodically adjust the frequency of trap checks in response to Project conditions. Changes in the frequency of trap checks will be reported annually (see Section 8.0). Through regular carcass persistence trials (Section 3.5), NPMPP will continue to measure probability of carcass persistence for surrogates of the Covered Species, and NPMPP will ensure that trapping efforts result in a mean carcass persistence time that meets or exceeds the search interval.

3.5.2 Vegetation management

To maximize the probability of detecting downed wildlife during searches NPMPP maintains vegetation within Standardized Search Plots at a height of 8 inches or lower through mowing or other means. Timing of mowing or other clearing activities that could destroy an undiscovered fatality are coordinated to ensure vegetation management occurs on the same day and after the completion of a search.

[9] The resident tenant farmers have small children and pets that could be injured in these traps. Considering the challenges of bilingual communication required, the risk of placement of traps in areas frequented by tenant farmers outweighs the potential benefits of specific trap placement within Supplemental Search Plots.

4.0 Calculation of the Proportion of the Carcass Distribution Searched

NPMPP has maximized the areas where scheduled searches are performed, while accounting for health and safety considerations associated with vegetation management and searching. The results of this effort, the use of highly trained canine search teams, weekly searches, intense vegetation management, where possible, and an expansive scavenger control program ensure that there is a very high probability of detecting a carcass that falls within the search plots. Below, Tetra Tech describes the conservative assumptions embedded in the analysis of the estimated carcass distribution searched as well as the results of the analysis.

4.1 Carcass Distribution Assumptions

Tetra Tech estimated the proportion of the carcass distribution within the Standardized Search Plots and Supplemental Search Plots (see Section 3.1) at the Project for the Hawaiian hoary bat and Covered Bird Species using a conservative interpretation of the Hull and Muir (2010) theoretical ballistics model. The Hull and Muir model was selected due to a lack of Project-specific empirical data, previous agency guidance, and the lack of well-supported alternative distribution models. USFWS and DOFAW (2018) provides additional guidance related to the calculation of the full search plot, specifically to consider the full carcass distribution for a turbine to include an additional 20 percent buffer on the downwind side of the turbine until Project-specific data regarding the actual fall distribution can be collected. However, USFWS and DOFAW (2018) lacks sufficient details and supporting scientific justification to allow for incorporation of this approach at sites, such as the Project, where full search plots are not achievable. We therefore have included a broadly conservative interpretation of the Hull and Muir model to assess carcass distribution at the Project. This is supported as the Project is a low wind speed site, and therefore the risk of significant wind drift of carcasses is relatively low.

Collision-associated fatalities are distributed at distances from turbines according to their mass with bats falling closer to the turbine than large birds (Hull and Muir 2010). Hull and Muir (2010) used ballistics models to estimate the proportion of carcasses of various sizes that fall within a given distance of turbines and were able to demonstrate consistency with field results on bat carcass distribution. Their analysis of turbines 149 meters tall estimated that 99 percent of large bird carcasses would fall within 116.5 meters of the turbine, 78 percent of the MBTH, and 99 percent of bat carcasses would fall within 66.5 meters, 47 percent of the MBTH of the turbine. Based on trends in their data, smaller birds would be expected to fall closer to a turbine than large birds, and all size classes would be expected to fall proportionally closer to the base of a larger turbine than to a smaller one.

Based on these conclusions, Tetra Tech incorporated two conservative assumptions into the analysis of carcass distribution searched: 1) all Covered Bird Species are treated as large birds and 2) the Project turbine is modeled using the large turbine data in Hull and Muir (2010) with the relative distance of the distribution modeled based on the proportion of the MBTH. Tetra Tech

interprets Hull and Muir (2010) data to yield theoretical carcass distributions based on proportions of the Project's MBTH, thus accounting for the larger turbine size at the Project than those represented in the Hull and Muir (2010) data set.

Because Hull and Muir (2010) suggest small birds fall closer to the base of a turbine than large birds, treating all Covered Bird Species as large birds is conservative (yielding a lower estimate of the carcass distribution searched). Hull and Muir (2010) used the wedge-tailed eagle (*Aquila audax*) for the large bird ballistics analysis, which is substantially larger than any of the Covered Bird Species. As an example of the conservative nature of this assumption, Hull and Muir (2010) estimate that 99 percent of large bird fatalities fall within 78 percent of the MBTH of a large turbine, while 99 percent of small bird fatalities fall within 54 percent of the MBTH of a large turbine. Thus, 99 percent of the medium-sized Covered Bird Species are likely to fall at a maximum distance from the turbine between 54 and 78 percent of the MBTH. Similarly, because results from Hull and Muir (2010) suggest that with increasing MBTH, individual classes of fatalities (i.e., bats, small birds, large birds) fall proportionately closer to the base of the turbine than for a comparable smaller turbine; therefore, the use of the large turbine data (which is smaller than the turbines at the Project) is conservative. For example, Hull and Muir (2010) estimates that 99 percent of large bird fatalities fall within 97 percent of the MBTH of a small turbine, 99 percent of large bird fatalities fall within 87 percent of the MBTH of a medium turbine, and 99 percent of large bird fatalities are estimated to fall within 78 percent of the MBTH of a large turbine. The effect is less pronounced but still present with bats. The turbines at the Project have a 16 percent greater MBTH (173 meters) than the large turbines analyzed by Hull and Muir (2010). This change is similar to moving from the Hull and Muir medium turbine MBTH to the Hull and Muir large turbine MBTH (19 percent increase in MBTH). In other words, it is conservative to assume that 99 percent of large bird fatalities will fall within 75 percent of the MBTH of the Project turbines because Project turbines are 16 percent taller than the large turbines analyzed by Hull and Muir, and it is expected that fatalities will fall proportionately closer to the Project turbine than the largest turbines analyzed by Hull and Muir.

The combination of the effect of larger turbine size with the expected increased proportion of Covered Bird Species falling closer to the base of the turbine than the modeled large bird (see explanation above), and the application of these conservative distribution assumptions uniformly around the turbine(relevant at a low wind site), provide a conservative estimate of the Covered Bird Species carcass distribution included in the searched area (Standardized Search Plots and Supplemental Search Plots combined). Similarly, because bat fatalities are expected to behave similarly based on the Hull and Muir model, with carcasses falling proportionately closer to the base of larger turbines than smaller ones, and through the application of this conservative distribution assumption uniformly around the turbine, our analysis provides a conservative estimate of the expected bat carcass distribution included in the search plots. Because the Project cannot implement scheduled searches beyond those already delineated within the search plots, much less across "full search plots," there is no opportunity to directly implement the USFWS and DOFAW (2018) guidance of increasing the full search plot by 20 percent on the downwind side to search for fatalities that fall outside of this area. The incorporation of these conservative

assumptions protects against the application of an overestimate of the proportion of the carcass distribution at this challenging site.

4.2 Estimated Carcass Distribution Searched

Results of this conservative analysis indicate that overall, approximately 71 percent of the bat carcass distribution and 37 percent of the Covered Bird Species distribution is being searched as part of scheduled searches (Table 1). NPMPP will work USFWS and DOFAW to incorporate results from new methods for estimating the carcass distribution at the Project if new scientifically supported and peer-reviewed approaches are identified, or Project data allows for the use of Project-specific empirical models.

To facilitate USFWS and DOFAW review of the estimated carcass distribution, Tetra Tech has supplied an Excel spreadsheet documenting the methodology used to develop the estimates. NPMPP has also provided shapefiles of the Project's Standardized Search Plots and Supplemental Search Plots.

Table 1. Proportion of Carcass Distribution by Turbine in Potential Search Plots

Turbine	Proportion of Carcass Distribution in Standardized Search Plots		Proportion of Carcass Distribution in Supplemental Search Plots[1]		Combined Proportion of Carcass Distribution	
	Bats	HCP Covered Bird Species	Bats	HCP Covered Bird Species	Bats	HCP Covered Bird Species
T1	0.72	0.34	0.0	0.0	0.72	0.34
T2	0.57	0.25	0.0	0.0	0.57	0.25
T3	0.71	0.32	0.0	0.0	0.71	0.32
T4	0.75	0.41	0.0	0.0	0.75	0.41
T6	0.77	0.36	<0.01	0.01	0.77	0.37
T7	0.70	0.32	0.08	0.17	0.78	0.49
T8	0.71	0.36	0.12	0.20	0.83	0.57
T9	0.57	0.21	0.00	0.00	0.57	0.21
Overall	**0.69**	**0.32**	**0.03**	**0.05**	**0.71**	**0.37**

1. Supplemental Search Plots where relatively consistent searches may be performed by the canine dog handler (Section 3.4).

5.0 Analysis Approach

As indicated above (see sections 3.1 and 3.4), PCMM results will be analyzed using the Evidence of Absence fatality estimation software program (Dalthorp et al. 2017). Results from the Standardized Search Plots and those Supplemental Search Plots which can be searched frequently enough to provide at least a 25 percent probability that a carcass would be discovered on the next search will

be combined using the multi-class module in the Evidence of Absence software to generate an overall probability of carcass detection at the end of each quarter. Due to substantially different conditions within the Supplemental Search Plots and the Standardized Search Plots, bias correction values (see sections 3.5.1 and 3.5.2) will be estimated separately for these two types of plots and combined. The results from the full fiscal year multi-class analysis will be used in the multi-year analysis to calculate the estimated take of Covered Species.

6.0 Wildlife Education and Incidental Reporting Program

NPMPP has developed a Wildlife Education and Incidental Reporting Program for contractors and Project staff who will be working at the Project during construction and operations. The Wildlife Education and Incidental Reporting Program facilitates incidental reporting and documentation of bird or bat fatalities that could occur outside of standardized carcass surveys. This training enables contractors and staff to identify the Covered Species that may occur in the Project site and trains them on appropriate actions. Staff are provided with printed reference materials that include photographs of each of the Covered Species, information on their biology and habitat requirements, threats to the species on site, avoidance and minimization measures being taken under the HCP, and appropriate actions to respond to dead or downed wildlife. Over the term of the HCP, the program will be updated, as necessary. In addition, NPMPP has actively worked with the private landowner and tenant farmers to ensure these individuals take appropriate measures to report dead birds or bats found at the Project to the Project's on-site manager. Any downed bird or bat identified through this system will be collected, documented, and reported according to the Downed Wildlife Protocol (DOFAW and USFWS 2020) and as described in Section 3.3.

7.0 Adaptive Management

NPMPP recognizes the unique challenges of performing PCMM at the Project resulting from a variety of factors described in the sections above (see sections 2.0, 3.1, and 3.4) and an associated obligation to periodically review conditions to consider if modification to the PCMM approach presented here is warranted. Specific challenges that may change over time and warrant periodic evaluation include:

- The regular presence of loose aggressive dogs in the vicinity of turbines 6 – 9 and
- Modification of agricultural use to allow increases or require decreases or a modified delineation of the Supplemental Search Plots.

NPMPP will work with the canine search team and the HCP compliance biologist to review the conditions at the site on an annual basis or as changed conditions are identified by field staff. In addition, the HCP compliance biologist will evaluate Non-searchable agricultural areas approximately monthly to consider if conditions have changed and would allow for reclassificaion and delineation of additional Supplemental Search Plots. Significant changes in conditions will be

reported (see Section 8.0) and discussed with DOFAW and USFWS annually. If significant changes allowing for the incorporation of additional Supplemental Search Plots or increasing the size of Standardized Search Plots to increase the estimate of carcass distribution searched (for birds or bats) by 5 percent or more at any individual turbine are identified, NPMPP will work with the wildlife agencies to incorporate updates to the search plots.

Additionally, NPMPP recognizes that fatality observations, possibly including incidental observations discovered outside of the search plots, may provide sufficient information to suggest that the actual carcass distribution at the Project turbines differs from that estimated. NPMPP will gather and evaluate Project results in comparison to the assumed distribution and consult with USFWS and DOFAW to update the carcass distribution analysis as observed fatalities of Covered Species (or similar other species) are identified. A minimum of ten observed fatalities similar to an individual Covered Species are required to attempt to assess the carcass fall distribution for the associated Covered Species at the Project.

8.0 Annual Report

The results of the Project PCMM will be included in the HCP annual report submitted to USFWS and DOFAW. The reporting schedule is outlined in Section 7 of the HCP. The HCP annual report will include results from the preceding year of surveys including:

- A summary of the results of the post-construction monitoring surveys including:
    - A list of Covered Species and other fatalities detected; and
    - Fatality location and detection information;
- Results of the carcass persistence trials and searcher efficiency trials;
- Adjusted take for Covered Species fatalities, including associated indirect take;
- Significant changes to conditions in the search plots; and
- Recommended changes, if any, to the monitoring protocols.

9.0 References

Dalthorp, D. M. Huso, and D. Dail. 2017. Evidence of absence (v2.0) software user guide: U.S. Geological Survey Data Series 1055, 109 pp. https://doi.org/10.3133/ds1055.

DOFAW and USFWS (Hawai'i Department of Land and Natural Resources—Division of Forestry and Wildlife and the U.S. Fish and Wildlife Service). 2020. Standard protocol for holders of a State of Hawai`i Incidental Take License and U.S. Fish and Wildlife Service Incidental Take Permit responding to dead or injured birds or bats that are threatened and endangered species or MBTA species.

Hale, A. and K.B. Karsten. 2010. Estimating bird and bat mortality at a wind energy facility in North-central Texas. Presented at the Wind Wildlife Research Meeting VII, Lakewood Colorado. October 19 – 21, 2010.

Hull, C.L. and S. Muir. 2010. Search areas for monitoring bird and bat carcasses at wind farms using a Monte-Carlo model. Australasian Journal of Wildlife Management 17: 77 – 87.

Tetra Tech, Inc. (Tetra Tech). 2016. Nā Pua Makani Wind Project Habitat Conservation Plan. Prepared for Nā Pua Makani Power Partners.

Tetra Tech. 2019. Kahuku Wind Power Habitat Conservation Plan FY 2019 annual report. Prepared for TerraForm Power.

USFWS and DOFAW. 2018. Wildlife agency standardized protocols for wildlife fatalities found outside the designated search area or discovered incidentally outside of a routine search. March 31, 2018.

Figures

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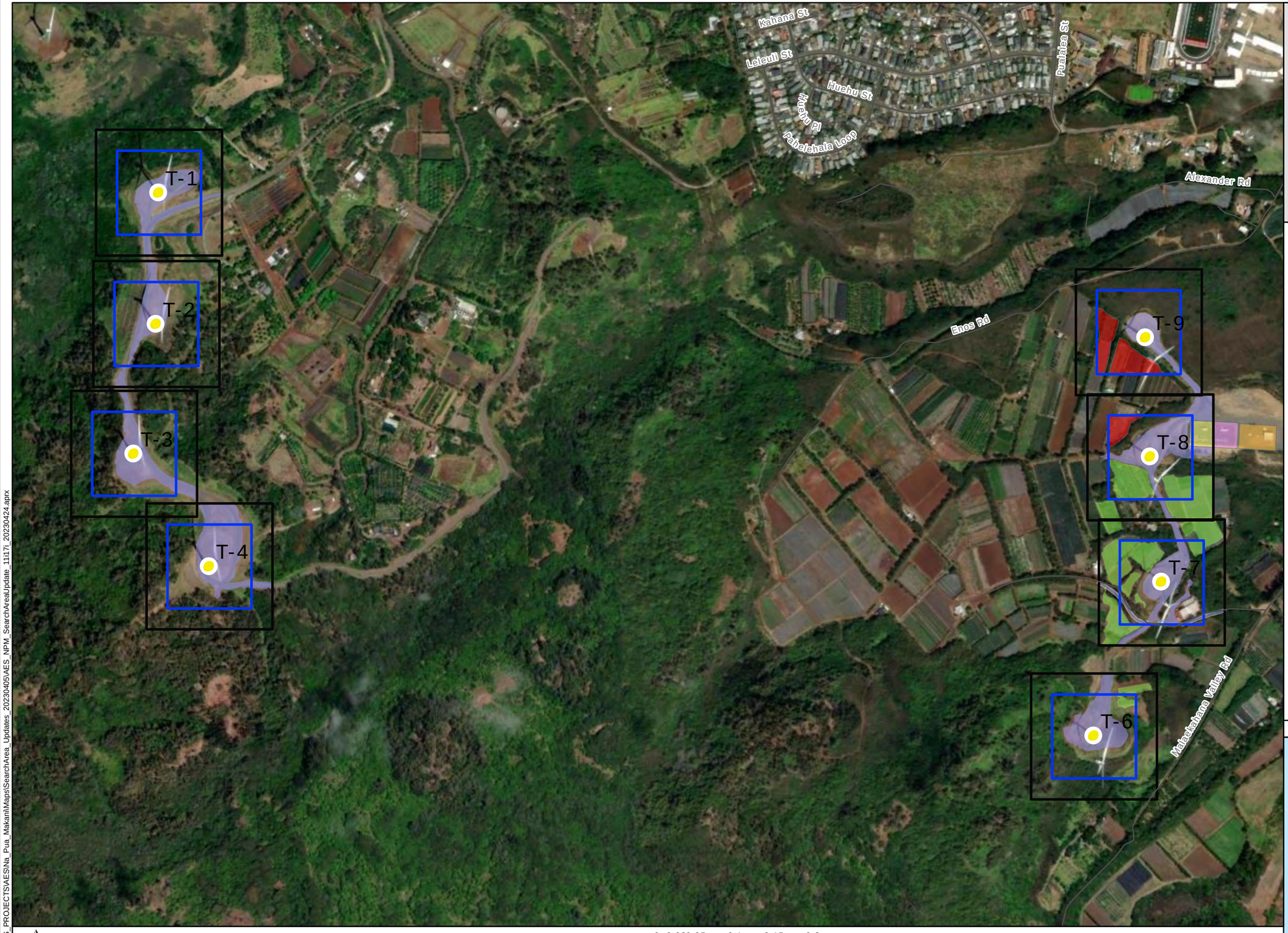
Nā Pua Makani Wind Project

Figure 1 Post-construction Mortality Search Plots

OAHU, HI

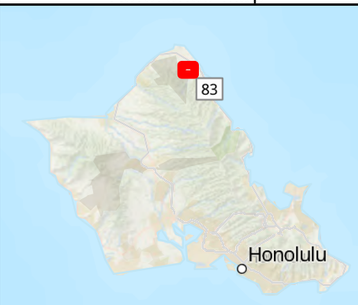


- Turbine
- 75% MBTH
- 50% MBTH
- CARE trial plots (not searchable due to aggressive dogs)
- Supplemental Search Plot
- Standardized Search Plot
- Substation
- HECO Switching Station
- O&M Building
- Local Roads

TETRA TECH

aes

Reference Map



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Nā Pua Makani Wind Project

Figure 1.1 Post-construction Mortality Search Plots T1

OAHU, HI

T-1

- Turbine
- 50% MBTH
- 75% MBTH
- Standardized Search Plot
- CARE trial plots (not searchable due to aggressive dogs)
- Supplemental Search Plot

TETRA TECH

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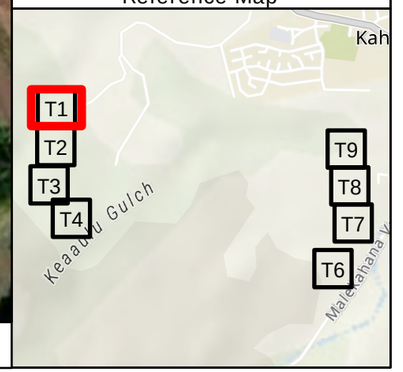
Reference Map



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Nā Pua Makani Wind Project

Figure 1.1 Post-construction Mortality Search Plots T1

OAHU, HI

- Turbine
- 50% MBTH
- 75% MBTH
- Standardized Search Plot
- CARE trial plots (not searchable due to aggressive dogs)
- Supplemental Search Plot

TETRA TECH

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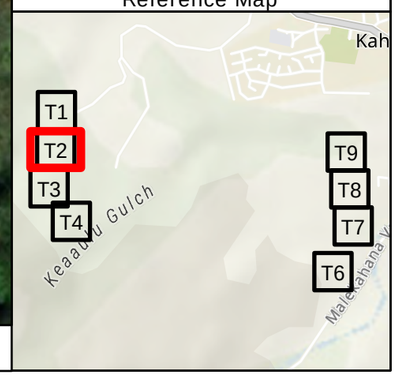
Reference Map



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Nā Pua Makani Wind Project

Figure 1.1 Post-construction Mortality Search Plots T1

OAHU, HI

T-3

- Turbine
- 50% MBTH
- 75% MBTH
- Standardized Search Plot
- CARE trial plots (not searchable due to aggressive dogs)
- Supplemental Search Plot

TETRA TECH

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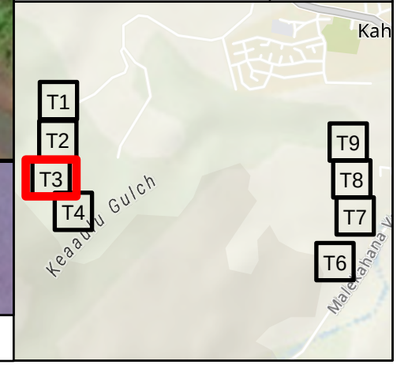
Reference Map



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Nā Pua Makani Wind Project

Figure 1.1 Post-construction Mortality Search Plots T1

OAHU, HI

T-4

- Turbine
- 50% MBTH
- 75% MBTH
- Standardized Search Plot
- CARE trial plots (not searchable due to aggressive dogs)
- Supplemental Search Plot

TETRA TECH

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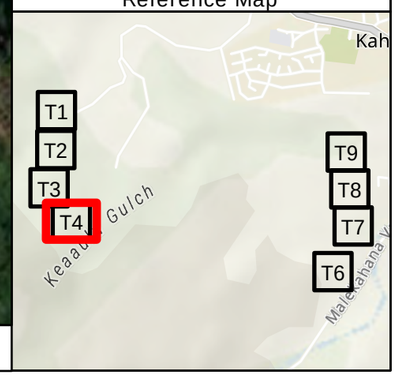
Reference Map



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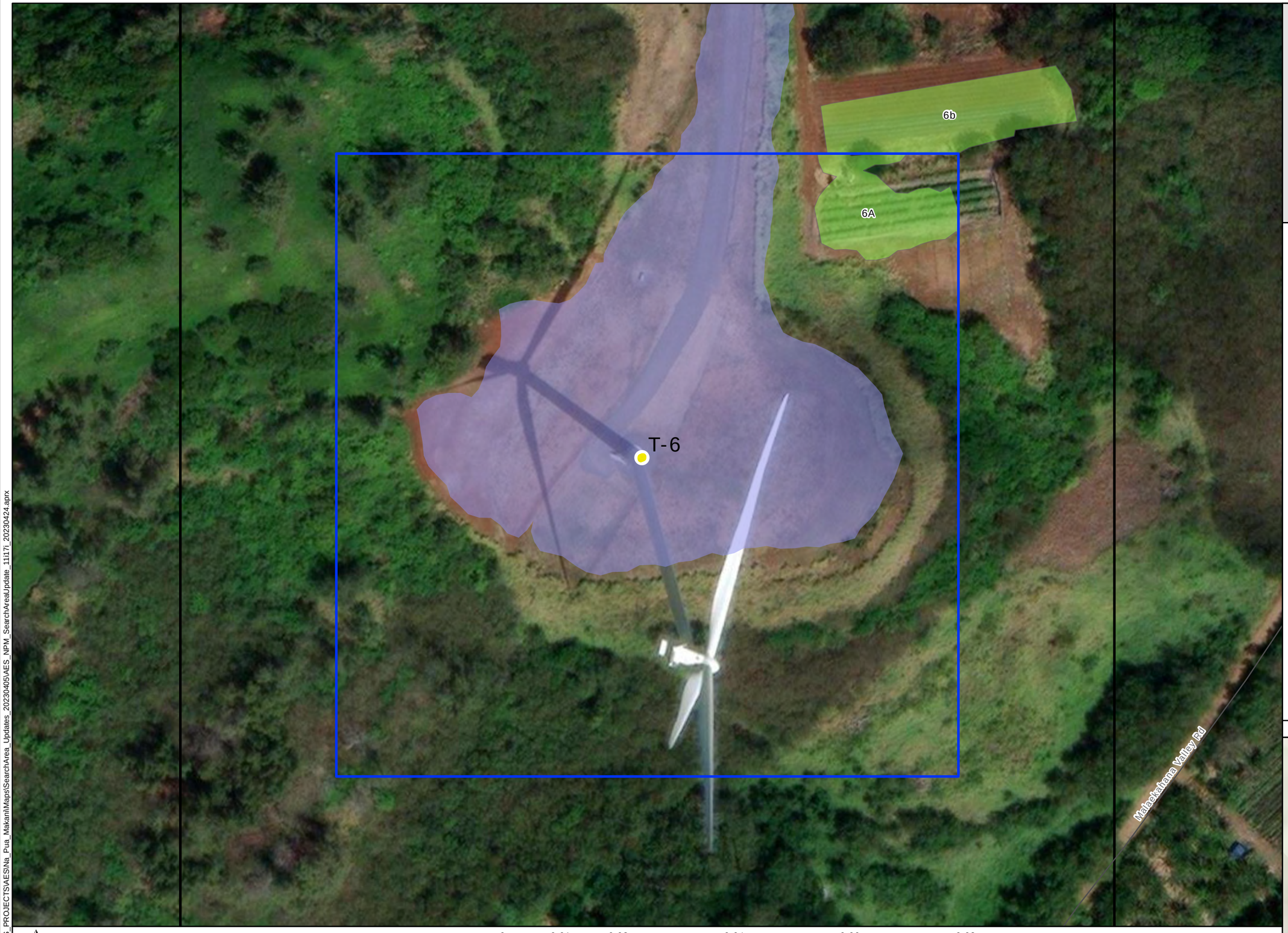
Nā Pua Makani Wind Project

Figure 1.1 Post-construction Mortality Search Plots T1

OAHU, HI



- Turbine
- 50% MBTH
- 75% MBTH
- Standardized Search Plot
- CARE trial plots (not searchable due to aggressive dogs)
- Supplemental Search Plot
- Local Roads

TETRA TECH

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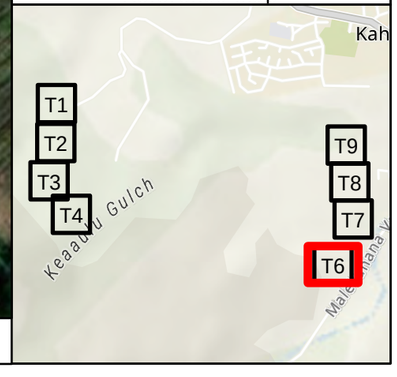
Reference Map



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Nā Pua Makani Wind Project

Figure 1.1 Post-construction Mortality Search Plots T1

OAHU, HI

- Turbine
- 50% MBTH
- 75% MBTH
- Standardized Search Plot
- CARE trial plots (not searchable due to aggressive dogs)
- Supplemental Search Plot
- Local Roads

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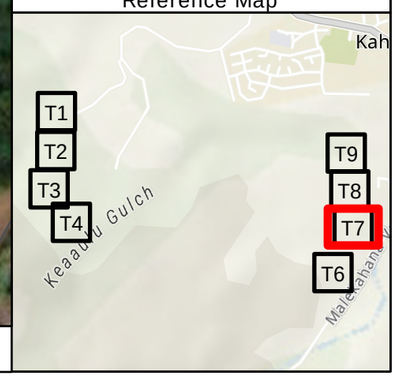
Reference Map



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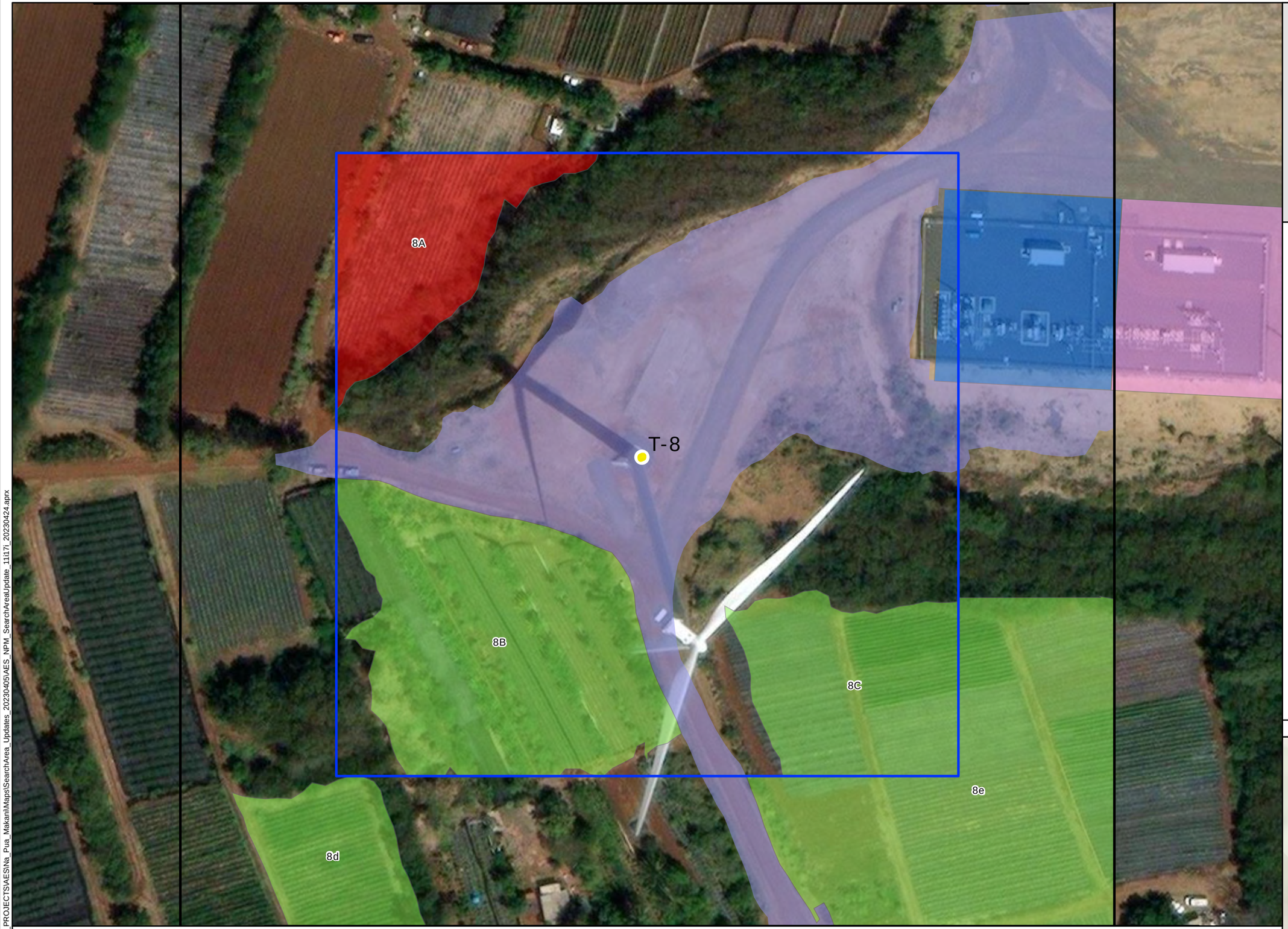
Nā Pua Makani Wind Project

Figure 1.1 Post-construction Mortality Search Plots T1

OAHU, HI

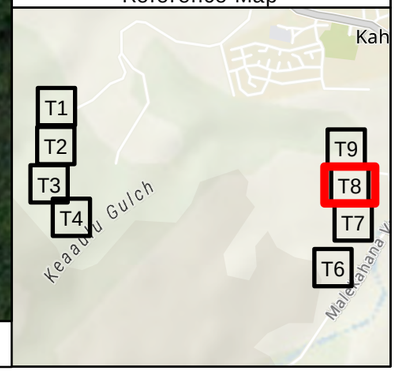


- Turbine
- 50% MBTH
- 75% MBTH
- Standardized Search Plot
- CARE trial plots (not searchable due to aggressive dogs)
- Supplemental Search Plot
- Substation
- HECO Switching Station

TETRA TECH

aes

Reference Map



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Nā Pua Makani Wind Project

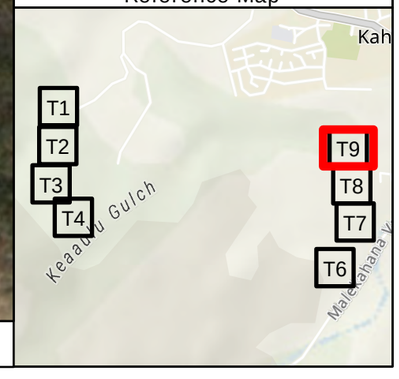
Figure 1.1 Post-construction Mortality Search Plots T1

OAHU, HI

- Turbine
- 50% MBTH
- 75% MBTH
- Standardized Search Plot
- CARE trial plots (not searchable due to aggressive dogs)
- Supplemental Search Plot
- Local Roads

TETRA TECH aes

Reference Map



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Nā Pua Makani Wind Project

Figure 2
Topography at Post-construction Mortality Search Plots
DLNR Ownership

OAHU, HI

T-1

T-2

T-3

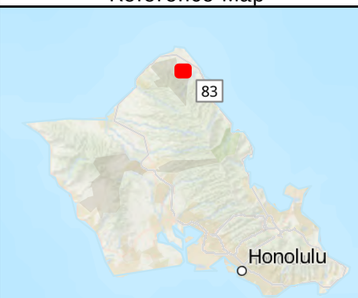
T-4

- Turbine
- 50% MBTH
- 75% MBTH
- Standardized Search Plot
- Substation
- Pre-construction O'ahu Elevation Contours 5ft
- Pre-construction Slope is greater than 15%

TETRA TECH

aes

Reference Map



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0 0.03 0.05 0.1 0.15 0.2
Miles

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Nā Pua Makani Wind Project

Figure 3
Topography at Post-construction Mortality Search Plots
Private Ownership

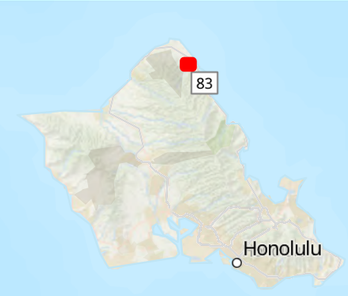
OAHU, HI

T-9
9A
9B
T-8
8A
8B
8C
8e
8d
7d
7e
7C
T-7
7A
7f
7B
7H
7g
T-6
6b
6A

Turbine
50% MBTH
75% MBTH
CARE trial plots (not searchable due to aggressive dogs)
Supplemental Search Plot
Standardized Search Plot
Substation
HECO Switching Station
Pre-construction O'ahu Elevation Contours 5ft
Pre-construction Slope is greater than 15%

TETRA TECH

Reference Map



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WGS 1984 UTM Zone 4N

0 0.03 0.05 0.1 0.15 0.2
Miles

NOT FOR CONSTRUCTION

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